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Mineral Resource Report 81

1981

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THE ORISKANY SANDSTONE IN THE SUBSURFACE OF PENNSYLVANIA

Kathleen D. Abel
Louis Heyman

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
OFFICE OF RESOURCES MANAGEMENT
BUREAU OF
TOPOGRAPHIC AND GEOLOGIC SURVEY
Arthur A. Socolow, State Geologist

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PENNSYLVANIA GEOLOGICAL SURVEY

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THE ORISKANY SANDSTONE IN THE SUBSURFACE OF PENNSYLVANIA

by

Kathleen D. Abel and Louis Heyman[1]

ABSTRACT

What has traditionally been called the Oriskany sandstone in Pennsylvania actually includes two different sandstones, each in a different area. These are the Ridgeley sandstone and a basal Onondaga sandstone. The Ridgeley sandstone is present throughout most of the study area but thins toward the northwest and finally disappears between Lawrence and Potter Counties. Northwest of the Ridgeley limit, a thin, patchy sandstone is present which is interpreted to be a basal Onondaga sandstone.

Oriskany (Ridgeley) production is related to both structural and stratigraphic-structural traps. A potential area for future Oriskany production is in Armstrong, Butler, and Lawrence Counties along the Ridgeley pinchout. Development of structural traps associated with subsurface overthrusting will also be important in the future. The thin, discontinuous Oriskany (basal Onondaga) sandstone in northwestern Pennsylvania is a possible secondary objective.

INTRODUCTION

The Lower Devonian Oriskany sandstone has produced natural gas in Pennsylvania since 1920, when the McCance pool in Westmoreland County was discovered. Initial potential of the discovery well was 500,000 cubic feet per day (Ashley and Robinson, 1922). Drilling to the Oriskany, however, was not intense until the discovery of the Leidy field, Clinton County, in which the discovery well had an estimated open flow of 15,000,000 cubic feet per day (Ingham, 1954). Although the Oriskany sandstone has been an important gas producer in Pennsylvania, there have been few published reports on it. Jones and Cate's (1957) regional study of the Devonian included an isopach and lithofacies map of the Ridgeley Formation of the Oriskany Group. There have also been two Oriskany field studies, one on the Leidy field (Ebright and Ingham, 1951) and one on the Elk Run pool (Heyman, 1969).

Although, in the past, the Oriskany sandstone has been considered as the same unit throughout the state, there has been some gamma-ray-log and

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[1] Gas Producing Enterprises, Inc., 415 West 8th Street, Amarillo, TX 79101.

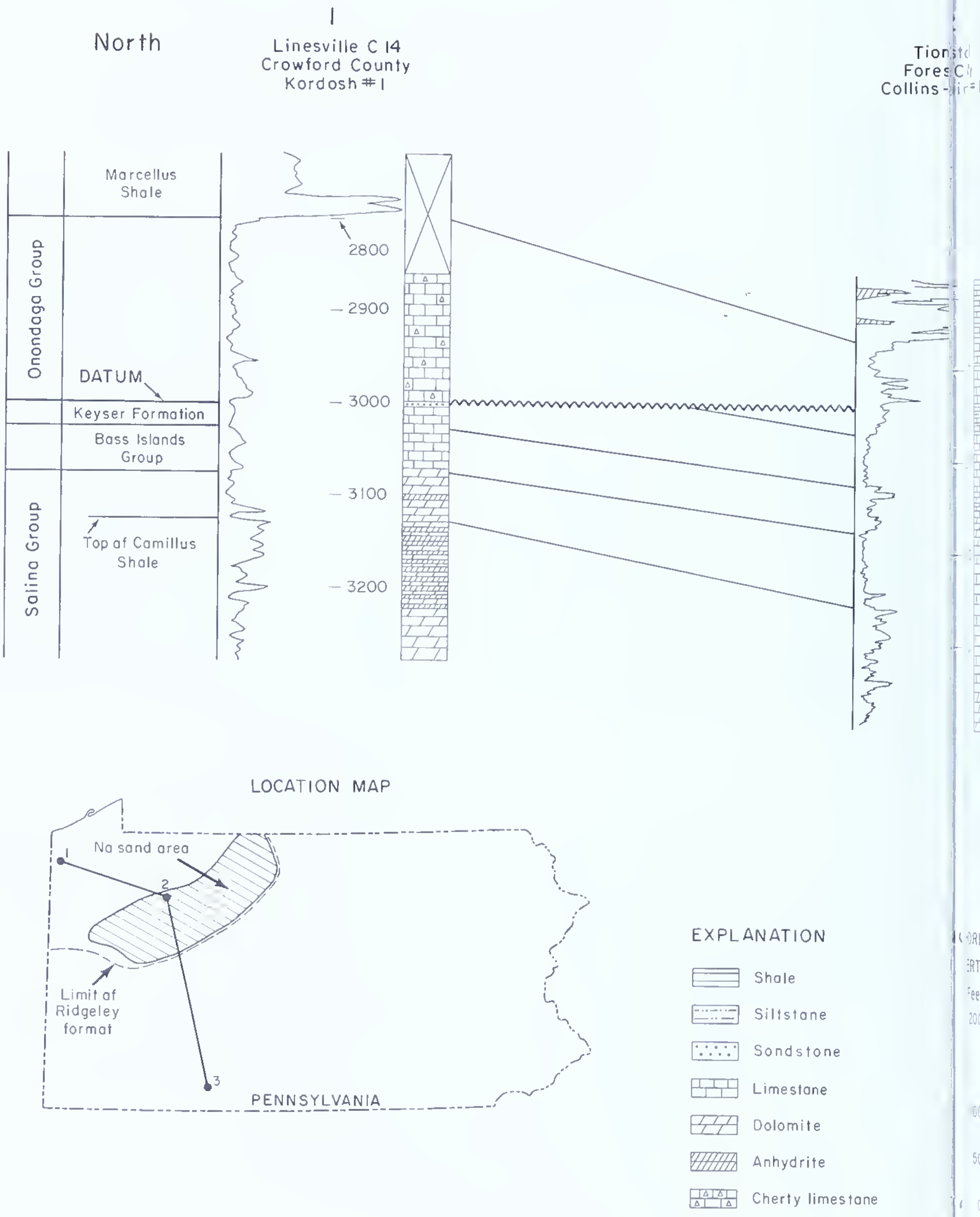
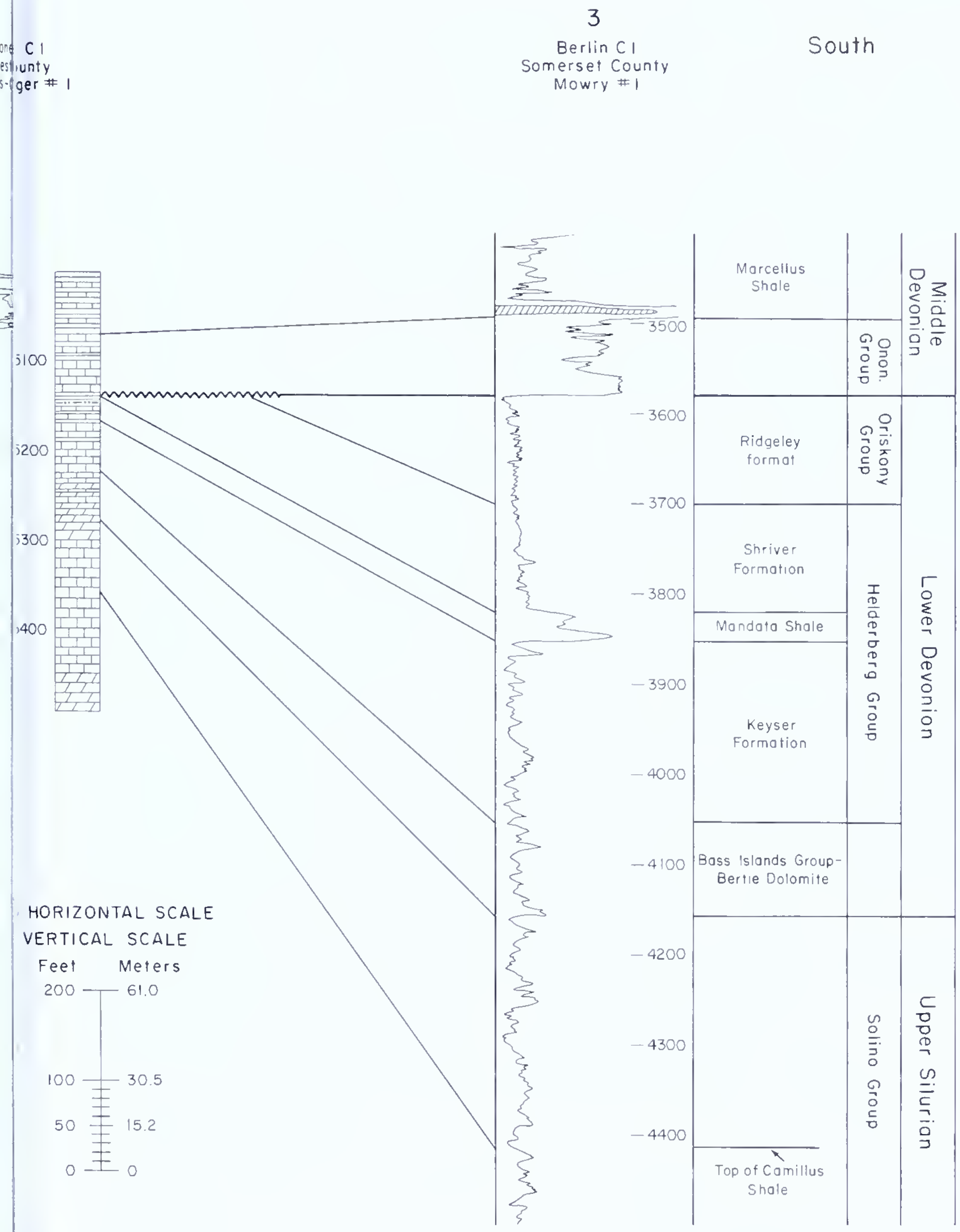


Figure 1. Cross section showing relationships of strata in the interv



from the Marcellus Shale to the Salina Group in western Pennsylvania.

sample evidence suggesting that the Oriskany comprises more than one sandstone. Heyman (1977) noted an unconformity in northwestern Pennsylvania and the absence of the Ridgeley sandstone in portions of that area. Additionally, the authors have noticed that the Oriskany sandstone in central Pennsylvania tends to be clean whereas the Oriskany sandstone in northwestern Pennsylvania more commonly contains glauconite and shale. Therefore, this study is in part an attempt to define and map the Oriskany sandstone on a regional scale. Another purpose of this report is to show where Oriskany production is and to predict where further production may be.

METHOD OF STUDY

In Pennsylvania, the name Oriskany sandstone has been applied to sandstone ranging from a basal sandy zone in the Onondaga limestone to a sandstone or sandy carbonate zone in the upper Helderberg Group (Heyman, 1977). Sandstone in the basal Onondaga is easily confused with Heyman's (1977) "true Oriskany" or Ridgeley Sandstone because basal Onondaga sandstone and Ridgeley Sandstone occupy roughly the same stratigraphic position, and in many places the basal sandstone is present where the Ridgeley is absent (Figure 1). To avoid confusion, and because of a lack of core data, the authors have used a gamma-ray format, the Ridgeley format, to define the study interval. A format (Forgotson, 1957) is a parastratigraphic rock unit bounded by markers that are based on relationships to a formal stratigraphic unit at one point or in one area, but that may cross facies boundaries and cutoffs. The use of the format is especially appropriate for subsurface correlations. The Ridgeley format in the subsurface of Pennsylvania is adapted from the work of Heyman (1977) and is related to the type Ridgeley Sandstone in West Virginia.

Where available, sample logs show that the Ridgeley format does not entirely comprise sandstone. Generally the format comprises sandstone underlain by limestone or interbedded sandstone and limestone.

In this report the authors follow drillers' terminology and call any sandstone at the Oriskany horizon (i.e., immediately below the carbonates of the Onondaga Group) Oriskany sandstone, but sandstone in the Ridgeley format is also specifically called Ridgeley sandstone. As used hereafter, Oriskany sandstone and Ridgeley sandstone are not formal names.

The cross sections of Heyman (1977) plus 13 new cross sections provided the framework for the Oriskany study. Using gamma-ray-log markers, the authors delineated the Ridgeley format in approximately 200 wells by correlations to the cross sections. Sandstone thicknesses were determined from sample logs for available wells and measured sections from a few outcrops. The data from the well correlations were used to construct the maps of this report.

EXPLANATION OF MAPS

RIDGELEY ISOPACH AND SUB-ONONDAGA SUBCROP MAP

Plate 1 shows the thickness of the Ridgeley format in Pennsylvania and the unit that underlies the Onondaga Group, as determined by gamma-ray-log picks. The Ridgeley format is a stratigraphic unit that is based on gamma-ray-log signature rather than on lithology. Contours at 50-foot intervals show general thinning of the Ridgeley format from southeast to northwest. The Ridgeley format has a maximum thickness of nearly 300 feet in southeastern Bedford County and disappears along a line extending from Lawrence County to Potter County, where it is truncated at a presumed unconformity (Heyman, 1977).

Southeast of the Ridgeley pinchout, the Ridgeley format is generally conformable with the overlying Onondaga Group and the underlying Helderberg Group; however, in some wells near the truncation of the Ridgeley format (zero contour line), the Ridgeley may be unconformably overlain by the Onondaga Group, as shown in Figure 1 (Heyman, 1977).

Northwest of the Ridgeley pinchout, progressively older units underlie the Onondaga Group, as a pre-Onondaga unconformity truncates progressively lower units (see Figure 1). Facies changes and basin-margin thinning as well as the unconformity may contribute to the disappearance of the Ridgeley format.

SANDSTONE THICKNESS MAP

Plate 2 shows the thickness of the Oriskany sandstone in Pennsylvania. The data on this map are from well sample logs or descriptions and from outcrop measurements. References for outcrop measurements are listed in Table 1. This map also shows the limit of the Ridgeley format (zero contour line of Plate 1). Because the Ridgeley format is defined by gamma-ray markers rather than lithology, it does not necessarily entirely comprise sandstone. It is also possible that a small amount of the sand that is termed Oriskany on sample logs from wells where the Ridgeley format is present actually belongs to the basal Onondaga or upper Helderberg. This map shows thickness of sandstone at the Oriskany horizon regardless of formation name.

Contours at 10-foot intervals show that sandstone thickness generally decreases from southeast to northwest and that northwest of the zero-Ridgeley contour the Oriskany sandstone is patchy, ranging from 0 to 30 feet thick. There is a large area having no sandstone extending from McKean County to Mercer County. This area coincides fairly well with the no-sand area of Jones and Cate (1957).

There is a general coincidence of the zero-Ridgeley contour and the southeastern edge of the no-sand area; between Potter and Armstrong

Table 1. *Sources for Outcrop Measurements*

Bedford County, Hyndman quadrangle, Clites Quarry—Willard and others (1939), p. 119-120.

Bedford County, Hyndman quadrangle, Koon Dam—Willard and others (1939), p. 120-121.

Bedford County, Hyndman quadrangle, Lake Gordon—Wallace de Witt, Jr., U. S. Geological Survey (personal communication of July 3, 1972); de Witt (1974).

Blair County, Hollidaysburg quadrangle, Bald Hill—Arndt and others (1959), p. 12-13; Willard and others (1939), p. 73-75.

Franklin County, Needmore quadrangle, Warren Point—Willard and others (1939), p. 105, 126-127; Cleaves (1937); Jones and Cate (1957), location 15.

Fulton County, Needmore quadrangle, Stillwell Ridge—W. D. Carter, U. S. Geological Survey (personal communication, September 22-30, 1975).

Fulton County, Needmore quadrangle, Tonoloway Ridge—W. D. Carter, U. S. Geological Survey (personal communication, September 22-30, 1975).

Lycoming County, Lock Haven quadrangle, Jersey Shore—Cleaves (1937), p. 64-71; Willard and others (1939); Ingram (1954); Jones and Cate (1957), location 8.

Lycoming County, Milton quadrangle, Montoursville—W. D. Carter, U. S. Geological Survey (personal communication, September 22-30, 1975).

Counties the two lines are within 3 miles of each other. From the zero-Ridgeley line toward the southeast the Ridgeley sandstone thickness generally increases to a maximum of 170 feet in southeastern Bedford County. A notable exception to the southeastward thickening trend is the anomalous thickening just southeast of the Ridgeley pinchout between southeastern Jefferson County and southwestern Potter County. Jones and Cate (1957) also noted this thickening and suggested that two parallel paleotopographic highs during Oriskany deposition (one northwest of the Ridgeley pinchout and the second approximately along the present Chestnut Ridge anticline) might account for the area of relatively thick sandstone between two areas of thinner sandstone.

Other anomalous thicknesses in south-central Pennsylvania may be apparent thicknesses caused by faulting or steep dips. Central Pennsylvania is an area of severe subsurface faulting and folding (McCaslin, 1980).

In Clarion County, within the no-sand area, is a patch of Oriskany sandstone that has been informally called the Clarion tongue of the Oriskany sandstone (Earl Linn, personal communication). We have no evidence that the Clarion tongue is part of the Ridgeley format, nor do any other wells northwest of the zero-Ridgeley contour correlate to the Ridgeley format.

ORISKANY PRODUCTION MAP

The production map (Plate 3) shows the outlines of fields and pools that produce or have produced natural gas from the Oriskany sandstone as of April 1, 1980, as well as representative dry holes. The scale of the map does not permit every dry hole to be shown. The well data are from well records submitted by drillers to the Pennsylvania Geological Survey. Field and pool names are from Lytle and Balogh (1977) and John Harper (personal communication). The map also shows the major anticlinal axes in Pennsylvania (from Fettke, 1954) and the limit of the Ridgeley format (see Plate 1).

Natural gas is present in both structural and stratigraphic-structural traps in the Ridgeley sandstone. Most of the Ridgeley fields in Pennsylvania are along or near the axes of anticlines. Examples of such fields are the Carrolltown field (Laurel Hill anticline) and the Sabinsville field (Sabinsville anticline). Faults also have a relationship to production; faults form boundaries to some pools, such as the Elk Run pool (Heyman, 1969) and the Leidy field (Ingham, 1954). Although the gas fields in southeastern Bedford County do not coincide with a major structural axis, their elongate shape suggests they are structurally controlled, probably by subsurface anticlines having no surface expression. In addition, southeastern Bedford County is where the greatest known thickness of Ridgeley sandstone occurs (Plates 1 and 2). The newest Oriskany fields, such as the Bakersville, Shamrock, and Rockwood fields in Somerset County, are structural traps associated with subsurface overthrusting. These fields are in the eastern overthrust belt, which extends from Alabama to Pennsylvania and is characterized by severe faulting and folding (McCaslin, 1980). The eastern overthrust belt, whose areal dimensions are still unknown, is the location of new exploration interest sparked by the discovery in 1979 of gas from the Oriskany sandstone in Mineral County, West Virginia.

Some fields, notably a series of pools in Jefferson, Clearfield, and Elk Counties, are related to the pinchout of the Ridgeley sandstone. Heyman (1969) attributed gas entrapment in the Elk Run pool, Jefferson County, primarily to a porosity loss which is about a mile downdip of the Ridgeley pinchout and which forms the northwestern boundary of the pool. The other boundaries are a fault on the northeast, a southwest-plunging nose on the southwest, and the gas-water contact on the southeast (Heyman, 1969). Note also that these pools in Jefferson, Clearfield, and Elk Counties coincide with the anomalous sandstone thickness in the same area (Plate 2).

There are a few Oriskany gas fields beyond the limit of the Ridgeley format, but most wells in northwestern Pennsylvania encounter salt water or no sand at the Oriskany horizon. For this reason Oriskany production in northwestern Pennsylvania is unpredictable, although the Oriskany may be a possible secondary target.

ORISKANY DRILLING DEPTH MAP

The drilling depth map (Plate 4) shows, at 1,000-foot contour intervals, the depth, in northern and western Pennsylvania, from ground surface to the top of the Oriskany sandstone and the areas of no sandstone at the Oriskany horizon (see Plate 2).

Drilling depth values are lowest in the northwest (less than 2,000 feet) and increase toward the southeast to a maximum of over 9,000 feet in Somerset and Cambria Counties. From there drilling depth decreases toward the Ridgeley outcrop along the Allegheny Front.

Although the contours reflect the generally steady southeasterly dip of the strata in northwestern Pennsylvania, this is not a structure-contour map. Drilling depth depends on surface topography, as well as on the structure of the formation. The map only shows how far one needs to drill to encounter Oriskany sandstone. For a structure-contour map on the top of the Oriskany, see Cate (1962).

CONCLUSIONS

The Oriskany sandstone of Pennsylvania apparently consists of two different sandstones, each in a different region. There are two lines of evidence to support this assertion. First is the absence of the Ridgeley format in northwestern Pennsylvania (see Plate 1). The Oriskany sandstone in the northwest cannot be correlated with the Oriskany sandstone in the rest of the state (Figure 1). Second is the difference in character of the sandstones in the two areas. The Ridgeley sandstone has a general pattern of thickening toward the southeast, but the Oriskany sandstone northwest of the Ridgeley pinchout shows no regular pattern (Plate 2). Also, the Ridgeley sandstone is cleaner; the sandstone in northwestern Pennsylvania more commonly contains glauconite and shale.

The Ridgeley sandstone is apparently a shelf deposit having its source to the southeast. The only evident pattern of deposition is thinning toward the northwest. The Ridgeley may or may not have been present over the entire state. There is a pre-Onondaga unconformity in northwestern Pennsylvania that could have been caused by either erosion or nondeposition. The pods of sandstone at the Oriskany horizon in northwestern Pennsylvania most likely are part of the lower Onondaga Group.

An alternate explanation is that all the sandstone is of the same formation and the areas of no sand in the northwest were caused either by local high areas present during deposition or by local erosion after deposition. One well, Goodwill #2, Erie I-115 (22A of Heyman, 1977) is known to have Oriskany-age fossils in the Oriskany sandstone, but these could have been reworked. Oliver (1967) noted Oriskany-type sand in the lower part of the Bois Blanc limestone outcrops in Ontario; he attributed this to reworking of Oriskany deposits in the early Bois Blanc sea. The Bois Blanc of Oliver (1967) is equivalent to the lower Onondaga in Pennsylvania.

The most likely area for future Oriskany production in Pennsylvania is the eastern overthrust belt in the central part of the state. Another promising area is just south of the Ridgeley pinchout in Armstrong, Butler, and

Lawrence Counties, especially along the anticlinal axes (of Kellersburg, Amity, and Greenville-Sprankle anticlines) that cross the Ridgeley pinchout line in Armstrong County.

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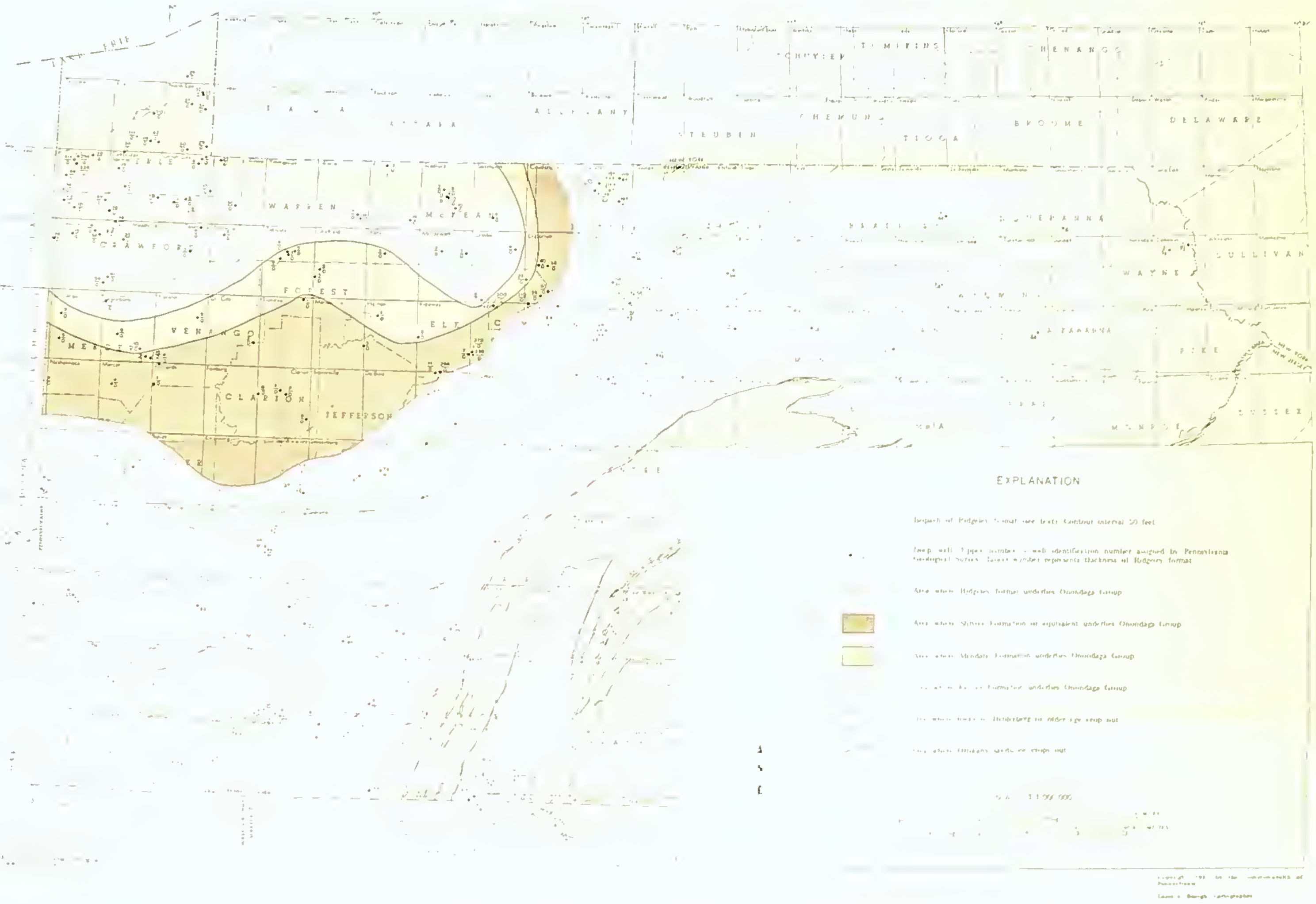
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CHAUTAUQUA
CATTARAUGUS
ALLEGANY
STEUBEN
SCHUYLER
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DELAWARE
ERIE
WARREN
McKEAN
CRAWFORD
FOREST
VENANGO
ELK
MERCER
CLARION
JEFFERSON
SUSQUEHANNA
WAYNE
SULLIVAN
PIKE
MONROE
SUSSEX
NEW YORK
EXPLANATION
Isopach of Ridgeley Formation (see text). Contour interval 20 feet
Deep well. Upper number = well identification number assigned by Pennsylvania Geological Survey. Lower number represents thickness of Ridgeley formation
Area where Ridgeley Formation underlies Onondaga Group
Area where Shriver Formation or equivalent underlies Onondaga Group
Area where Mandata Formation underlies Onondaga Group
Area where ... Formation underlies Onondaga Group
Area where rocks of Helderberg or older age crop out
Area where Oriskany rocks crop out
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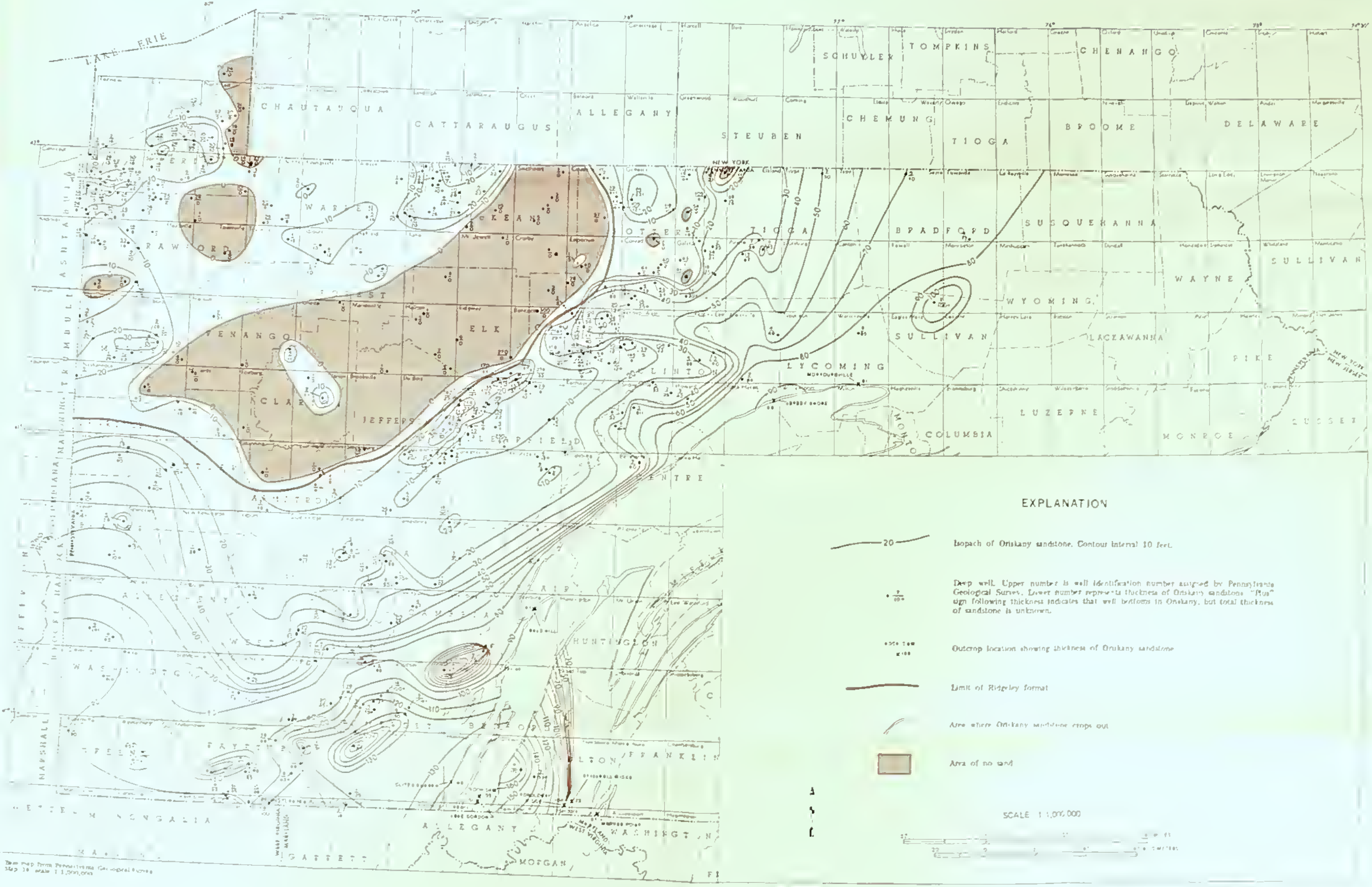
PLATE 1. RIDGELEY ISOPACH AND SUB-ONONDAGA SUBCROP MAP



EXPLANATION

Isopach of Oriskany sandstone. Contour interval 10 feet.

Deep well. Upper number is well identification number assigned by Pennsylvania Geological Survey. Lower number represents thickness of Oriskany sandstone. "Plus" sign following thickness indicates that well bottoms in Oriskany, but total thickness of sandstone is unknown.

Outcrop location showing thickness of Oriskany sandstone

Limit of Ridgeley format

Area where Oriskany sandstone crops out

Area of no sand

SCALE 1:1,000,000

Base map from Pennsylvania Geological Survey Map 10, scale 1:1,000,000

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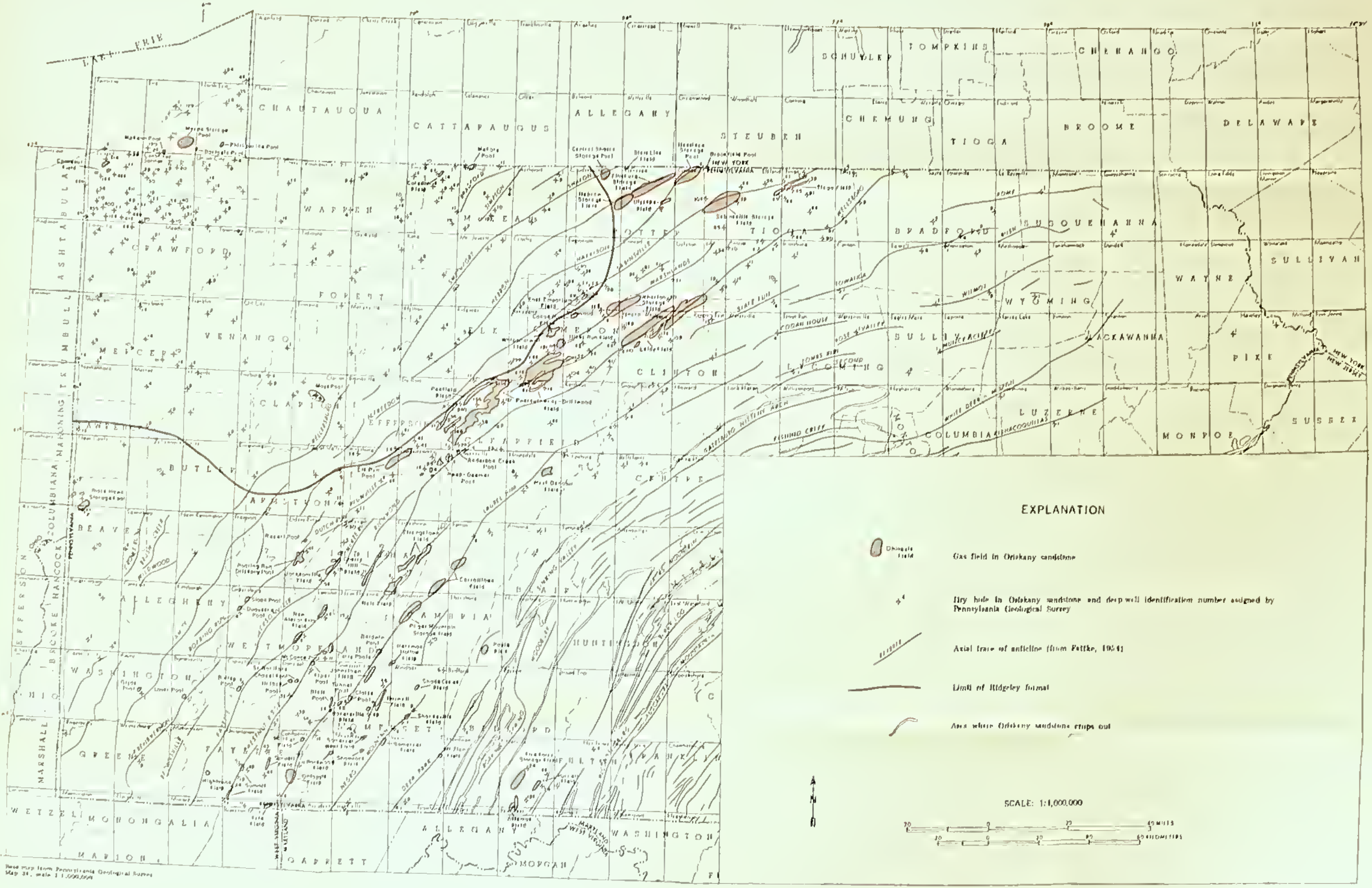
PLATE 2. ORISKANY SANDSTONE THICKNESS MAP



EXPLANATION

Chipmunk Field — Gas field in Oriskany sandstone

Dry hole in Oriskany sandstone and deep-well identification number assigned by Pennsylvania Geological Survey

Axial trace of anticline (from Fettke, 1954)

Limit of Ridgeley format

Area where Oriskany sandstone crops out

SCALE: 1:1,000,000

Base map from Pennsylvania Geological Survey
Map 31, scale 1:1,000,000

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PLATE 3. ORISKANY PRODUCTION MAP

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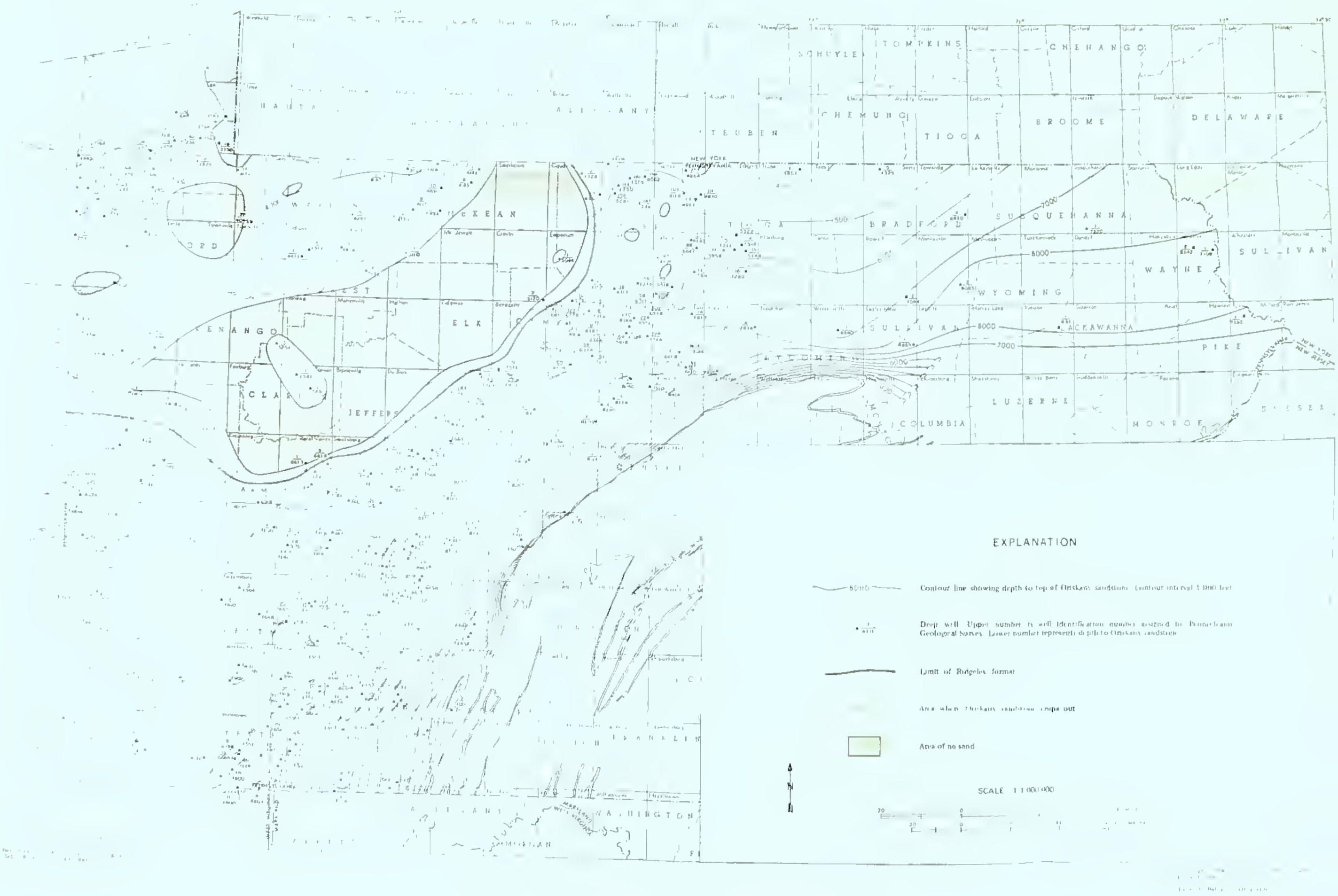

PLATE 4. ORISKANY DRILLING DEPTH MAP